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ABSTRACT

Infants in four age groups--three, six, nine and twelve months--were exposed to an experimental procedure designed to assess the extent to which such subjects were capable of discriminating between different orientations of the same form, and the extent to which they were capable of recognizing the identity between different orientations of the same form. Results revealed that from at least as early as six months-infants manifest both kinds of perceptual ability. (Author)

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INFANT DISCRIMINATION OF ORIENTATION

Harry McGurk

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Infant Discrimination of Orientation

Harry McGurk
Educational Testing Service

Abstract

Infants in four age groups—3, 6, 9 and 12 months--were exposed to an experimental procedure designed to assess the extent to which such subjects were capable of discriminating between different orientations of the same form, and the extent to which they were capable of recognizing the identity between different orientations of the same form. Results revealed that from at least as early as 6 months infants manifest both kinds of perceptual ability.

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Infant Discrimination of Orientation[1]

Harry McGurk

Educational Testing Service

The role of orientation (i.e. the extent to which a stimulus is rotated about the origin of its horizontal and vertical axes) as a factor in stimulus perception and recognition has been of recurrent interest to psychologists. Frequently the issue has been examined in a developmental context and the question asked whether stimulus orientation plays an equal role in perception by younger and older subjects. Until relatively recently, the answer was regarded as quite unequivocal; it was generally accepted that the younger child recognised a form equally well in any orientation, that he did not discriminate between different orientations of the same form and, consequently, that orientation did not influence young children's form perception. It was believed that only with increasing age did children come to discriminate orientation, this process continuing into adulthood when perception was regarded as being much more orientation-specific than in children. Studies by Rice (1930), Davidson (1934, 1935), Newhall (1937), Ling (1941) and Gibson, Gibson, Pick and Osser (1962) all seemed to support this conclusion, and it became the standard text-book view (e.g. Jersild, 1933; Mussen, Conger & Kagan, 1963).

Since the mid-1950's, the unanimity previously obtaining in this field has been seriously disrupted. Hunton, (1955) in a study involving subjects between 2 and 14 years, argued that initially children learn to recognise a form in its familiar, upright orientation and only with increasing age

do they become able to recognise stimuli independently of orientation. Ghent and her colleagues (Ghent, 1960, 1961, 1964; Ghent & Bernstein, 1961; Ghent, Bernstein & Goldweber, 1960) have also argued that younger children are particularly dependent upon the upright orientation for form recognition and that such dependence decreases with increasing age. Such conclusions, of course, directly contradict the earlier view.

With few exceptions (e.g. Watson, 1966) none of the earlier studies of orientation discrimination have involved subjects younger than 18 months or so. Thus, in addition to the confusion over the role of orientation at later stages in development, almost nothing is known of the influence of orientation on perception during early infancy. Yet, it is important for an understanding of early perceptual and cognitive development to know whether the young infant lives in a visual world in which stimuli are recognised regardless of the orientation in which they are encountered or one in which such recognition is orientation-specific. Clearly, the latter would be a more complex, less stable world than the former.

McGurk (1970) observed that 6- to 26-week-old infants showed systematic decline in visual attention over successive presentations of a constant stimulus and showed significant attentional recovery when stimulus orientation was subsequently modified. This occurred both with a three-dimensional facial object and with a two-dimensional, funnel-shaped stimulus. It was concluded that these infants discriminated between different stimulus orientations but, because of the small sample size, this conclusion had to be regarded as tentative. The present study, which was restricted to two-dimensional stimuli, was undertaken in an attempt to replicate the earlier finding on a larger sample, to determine also if young infants recognised the identity between different orientations of the same form and to isolate

any developmental changes occurring in infant sensitivity to orientation during the first year of life. The procedure adopted was similar to one followed in the earlier study and was based on the violation of expectancy paradigm reported by Lewis and Goldberg (1969). The basic procedure involves two phases, a familiarisation or habituation (S_1) and a violation phase (S_2). The S_1 phase involves repeated presentation of a constant stimulus. Any attentional decrement occurring during this phase is regarded as evidence that the subject is acquiring an expectancy for the appearance of the S_1 stimulus. After a series of S_1 trials, a new stimulus, S_2, is presented and the magnitude of any attentional recovery provides an index of the subject's ability to discriminate between S_1 and S_2.

The present experiment incorporated three familiarisation, or S_1, conditions. The index of attention exmployed was duration of fixation upon stimuli. Under one condition, a single figure was repeatedly exposed in a constant orientation; fixation responses under this condition would illustrate the temporal pattern of infant attention to an unchanging stimulus. Another condition involved successive presentation of a series of different figures; fixation data here would illustrate the pattern of attention when form varied from one exposure to the next. The third condition again involved repeated presentation of the same figure, but now orientation varied from one exposure to another. For subjects who recognised the identity between different orientations of the same form, the attentional pattern under this third condition would be more similar to that when the stimulus remained constant from trial to trial than when a new figure was presented on each trial. On the other hand, for subjects

for whom identity was orientation-specific, the attentional pattern when orientation was varied from trial to trial would be similar to that shown when an objectively different figure was presented on each trial. This, in brief, was the rationale upon which the familiarisation phase of the experiment was based. The design also incorporated two violation, or S_2, conditions representing, respectively, change of orientation and change of identity. It was expected that responses to violation stimuli would be influenced by the nature of the familiarisation condition to which subjects had previously been exposed.

METHOD

Subjects

Subjects, 144 infants between 10 and 54 weeks, were tested at various infant welfare clinics in Glasgow. There were four age groups, 3 months ($\bar{X}$ = 13.3 weeks; s.d. = 1.05 weeks), 6 months ($\bar{X}$ = 26.1; s.d. = 1.35), 9 months ($\bar{X}$ = 38.9; s.d. = 1.28) and 12 months ($\bar{X}$ = 51.2; s.d. = 1.20). Each group, of 36 Ss, had approximately equal numbers of males and females. Subjects were primarily from families of moderate socioeconomic status. An additional 50 infants with whom testing was begun were excluded from the final sample due to excessive fretting, sleepfulness, failure to attend at all to stimuli or maternal intervention in the procedure.

Apparatus

Stimuli were rear-projected onto a milk-glass screen centrally located on the front panel of a three-sided, U-shaped surround. The screen was 14 inches square. The surround was 4 feet 6 inches high and its front and side panels were 3 feet wide. All surfaces were painted matt white,

thus providing a relatively homogeneous, perceptually neutral environment. There was a 0.25 inch peep-hole on either side of the screen. Subjects' fixations onstimuli were observable via these holes.

The projector automatically advanced at alternate 20 and 10 second intervals, corresponding, respectively to duration of trials and inter-trial intervals. Hardboard shields in alternate locations of the magazine cut off illumination to the screen during inter-trial intervals. A Rustrak event recorder was used to record stimulus onset and offset and to record duration of fixations on stimuli.

Abstract figures were employed as stimuli under the three familiarsation conditions of the main part of the experiment and a different set of stimuli was prepared for each condition. These were: (1) constant form and constant orientation (FCOC): the set corresponding to this condition comprised four instances of the same abstract figure in an upright orientation; (2) constant form and variable orientation (FCOV): the same figure was employed as for the FCOC condition, but now it appeared in four orientations, 0, 90, 225 and 315 degrees; (3) variable form and constant orientation (FVOC): here stimuli comprised four different figures, one the same as in the FCOC condition and three others. All FVOC figures were in an upright orientation.

Violation stimuli were also prepared. These comprised the 180 degree orientation of the FCOC figure and the upright orientation of a figure not previously employed in any condition. All figures were adapted from Ghent (1961). Each had a clear focal point (cf. Ghent, 1961), and the upright or 0 degrees orientation was defined with respect to the spatial location of this point. Examples of stimuli are presented in Figure 1.

PS 05752

Figure 1 about here

Stimuli were prepared by photographing white on black drawings of the figures. When projected onto the screen, the upright orientation of each figure subtended a visual angle of approximately 20 degrees.

Social stimuli were presented during filler trials (see below). These comprised upright and upside-down orientations of a schematic drawing of a human face.

Procedure

Equal numbers of Ss from the four age groups were randomly assigned to each familiarisation condition. Under each condition Ss were exposed to two identical familiarisation episodes, each comprising 4 x 20 second trials. Each episode was followed by a single 20 second trial during which one of the violation stimuli was presented. A different violation stimulus followed each familiarisation episode and the sequence of violation by form change and by orientation change was counterbalanced across Ss. A series of filler trials occurred between the two familiarisation-violation sequences. These comprised four familiarisation trials with the upright facial stimulus and one violation trial during which the face was presented upside-down. Filler trials were included to facilitate recovery from any general habituation which may have occurred to the stimuli presented during the preceding experimental episode.

All Ss experienced the same violation stimuli, but the nature of the stimulus change involved can be viewed as a priori different following different familiarisation conditions. Reference to Figure 1 shows that for FCOC subjects, both violation stimuli represented variations on dimensions that had been constant during familiarisation. For FCOV subjects, one violation stimulus (form change) involved variation on a previously constant dimension while the other represented further variation on a dimen-

sion which had varied throughout familiarisation. For FVOC subjects, form varied during familiarisation and varied further on one violation trial; the other violation stimulus involved change of orientation, a dimension which had been constant during familiarisation.

Subjects were tested individually in a room at the local clinic. Each S was accompanied by the mother who sat on a low chair situated within the surround. The baby sat on the mother's knee, facing the screen. With this arrangement the center of the screen was approximately at the infant's eye-level, at a viewing distance of about 20 inches. Mothers were instructed to sit with the baby like this until testing was completed and were asked not to speak to the infant nor to encourage him in any way to look at the screen. During these preliminaries a target stimulus (animal face) was projected onto the screen and its presence was sufficient to ensure that, at least initially, S's head and eyes were oriented toward the screen.

Experimental stimuli were presented with the room darkened. Under these conditions Ss' fixations upon stimuli were clearly visible to an observer via the peep-hole. Fixation was defined as occurring whenever S's head and eyes were oriented towards the screen and there was an image of the stimulus reflected off the cornea, above the pupil. Duration of such fixations was recorded by means of a press-switch. Actual testing time occupied 7.5 minutes.

RESULTS

Familiarisation Data

Each S experienced two four-trial familiarisation episodes, and analysis was based upon total fixation time per trial, averaged across episodes.[2] Results of the Age x Familiarisation Condition x Trials (4 x 3 x 4) analysis

of variance applied to these data are summarised in Table 1.

Table 1 about here

The main effect for age indicates that 3-month-old Ss had longer overall fixation times than Ss in the other three groups; the latter differed little from each other. The effect for familiarisation conditions and the Age x Familiarisation Condition interaction effect together indicate that a tendency for more overall fixation to occur under the FVOC condition than under the other two conditions was restricted to 6-, 9-, and 12-month-old Ss. Within Ss, the main effect for trials signifies a tendency for fixation times to decrease over successive trials. However, the various interaction terms indicate that this effect was restricted (a) to 6-, 9-, and 12-month infants and (b) to FCOC and FCOV conditions. No group of Ss showed response decrement under the FVOC condition and 3-month-olds failed to show decrement under any condition. All of the above effects are apparent in Figure 2.

Figure 2 about here

Violation Data

Each S experienced two violation conditions at Trial 5, representing, respectively, change of orientation and change of form. Analysis of responses to these stimulus changes was based on the difference between total fixation during the final familiarisation trial (Trial 4, averaged across episodes) and total fixation during each violation trial. Every S thus had two difference scores, one for each violation condition, and these were analysed in the Age x Familiarisation Condition x Violation Condition

(4 x 3 x 2) analysis of variance summarised in Table 2.

Table 2 about here

The main effect for age in Table 2 indicates that 3-month Ss had lower difference scores than Ss in the other three groups. The effect for familiarisation conditions and the interaction between age and familiarisation conditions together indicate that while difference scores of 6-, 9-, and 12-month-old Ss were influenced by the nature of the familiarisation experience, such influence was absent from the 3-month data. As can be seen in Figure 2, differences in fixation time between Trials 4 and 5 were, in general, large and positive following form change under FCOC and FCOV conditions; these have combined to produce an apparent effect for violation conditions. Of more interest, however, are the significant interaction effects between familiarisation and violation conditions, and between age, familiarisation conditions and violation conditions. The meaning of these interactions is clear from Figure 2. It can be seen that the effect for violation conditions was different for 3-month Ss compared with older Ss. The response of youngest Ss to the different kinds of stimulus change was slight and varied little between familiarisation conditions; none of the differences between Trials 4 and 5 was statistically significant at 3 months. On the other hand, for 6-, 9-, and 12-month Ss, change of form and change of orientation both elicited increased fixation under the FCOC condition (by t-test, $p < .01$ in each instance). Under the FCOV condition, only change in form elicited significant increase in fixation on the part of 6-, 9-, and 12-month Ss (by t-test, $p < .01$) in each instance); here, change in orientation merely resulted in continuation of the response pattern

observed during familiarisation trials, though there were minor differences between age groups in this respect. Finally, under the FVOC condition, neither form nor orientation change elicited significant increase in fixation times at Trial 5 at any age.

Filler Trials

Fixation data from the filler trials, during which Ss were exposed to a facial stimulus, are presented in Figure 3. Age x Trials (4 x 4) analysis of responses during the four familiarisation trials yielded significant effects for age ($F(3, 140) = 14.75$; $p < .001$), for trials ($F(3, 420) = 44.12$; $p < .001$), and for interaction between age and trials ($F(9, 420) = 6.42$; $p < .001$). The interaction effect indicates that response decrement over successive trials was restricted to 6-, 9-, and 12-month Ss. The main effect for age merely indicates that 3-month Ss again had longer overall fixation times, a consequence of their failure to show any decline in fixation across trials.

Figure 3 about here

On the fifth filler trial, the previously upright face was presented upside-down. To assess response to this change, an Age x Trials (4 x 2) analysis of variance was applied to fixation times during the final familiarisation trial (4) and the violation trial (5). Again, there were significant effects for age ($F(3, 140) = 15.08$; $p < .001$), trials ($F(1, 140) = 93.44$; $p < .001$), and for Age x Trials interaction ($F(3, 140) = 7.12$; $p < .001$). From Figure 3 it is clear that the interaction effect again signifies a difference between 3-month and older Ss; whereas 6-, 9-, and 12-month Ss showed marked increases in fixation between Trials 4 and 5, 3-month Ss' fixations

were maintained at their previously high level, this being the source of the significant age effect.

DISCUSSION

In terms of the experimental paradigm outlined earlier, only infants of 6 months and older can be said to have discriminated between different orientations of the same form. Only such infants manifested consistent and significant attentional decrement over successive familiarisation trials with a constant stimulus, and only they manifested significant recovery of attention when orientation was subsequently modified, thus signifying their perception of the change. Younger subjects failed to show any habituation of attention during familiarisation trials with the constant stimulus (or under any other condition); consequently, there was little likelihood of their showing response recovery per se during violation trials, regardless of whether the stimulus changes introduced then were discriminated by them. Such age differences in orientation discrimination were observed in respect of social and abstract stimuli.

Infants of 6 months and older, although capable of discriminating orientation differences, nonetheless recognised the identity between different orientations of the same form. The principal evidence for this conclusion comes from the performance of 6-, 9-, and 12-month subjects exposed to the FCOV familiarisation condition. During familiarisation these subjects were presented with different orientations of the same form. The pattern of their attentional decline was similar to that of comparable subjects exposed to the same figure at a constant orientation. If subjects familiarised under the varying orientation condition had been unable

to recognise the similarity between stimuli encountered on successive trials, if for these subjects identity had been orientation specific, then they would have been expected to show a response pattern more similar to that of their counterparts who encountered an entirely different figure on each familiarisation trial (FVOC condition). Latter subjects showed little evidence of systematic response decrement.

The behaviour of 6-, 9-, and 12-month FCOV subjects during violation trials supports the above interpretation. When violation was by change of form, these subjects manifested significant recovery of attention. In this respect their behaviour was again like that of infants familiarised under the constant orientation condition; the latter also showed significant response recovery when a new form was presented at Trial 5. However, when the violation trial involved change in orientation, a dimension which had varied throughout familiarisation, FCOV subjects showed no response recovery. In this respect they were unlike their FCOC counterparts who showed recovery not only to change of form but also to change of orientation. Subjects familiarised under the FVOC condition showed no response recovery under either violation condition.

Unfortunately, present findings afford no information on the role of orientation in form perception by 3-month-old-infants, primarily because their attentional behaviour was insensitive to the experimental conditions manipulated here. Such young infants may or may not discriminate between different orientations of the same form, may or may not recognise the same form in different orientations, but because of their failure to show either response decrement or response recovery under any of the treatment combinations, no conclusions can be drawn in this respect. This may indi-

cate a need for re-evaluation of the generality of the habituation/recovery paradigm as an experimental technique. Currently there is some confusion in the literature over whether infants as young as 3 months show habituation of attention under the kinds of conditions studied here. Positive results have been reported by Caron and Caron (1968, 1969), McGurk (1970), and Friedman (1971); on the other hand, negative findings have been obtained by Fantz (1964), Fantz and Nevis (1967) and Lewis, Goldberg and Campbell (1969). These studies, however, differed from each other on a number of parameters--nature of stimuli and method of presentation, number and duration of presentations, duration of intervals between presentations. There is clearly a need, therefore, for systematic examination of the various parameters that might influence infant responding in the situation under study. In this way, it may become possible to identify the conditions under which very young infants do and do not show habituation of attention.

Due to the inconclusiveness of results from 3-month-old infants, present findings are less precise than one would have wished concerning the age at which orientation discrimination first occurs. Similarly, the issue remains unresolved of whether the infant first perceives the identity or form of a stimulus, regardless of orientation, and only later learns to discriminate orientation; or whether orientation-specific perception appears first and the infant later learns that the identity of a form remains invariant through orientation change. What is clear, however, is that from at least as early as 6 months, orientational differences are registered by the infant's visual system (possibly in the fashion outlined

by Hubel, 1963) and that under certain circumstances the young infant attends to such differences and discriminates between stimuli on this basis. It is also clear, however, that under other circumstances, orientation remains relatively unattended and the infant attends more to the identity between different orientations of the same form. The latter is an adaptive strategy and ensures a primitive kind of object constancy under conditions of perceptual change. Because of its adaptiveness, this may indeed become the dominant mode of responding and may lead to confusion of orientation at later stages in development. However, the present research has shown that whenever such confusion arises, it cannot be attributed to any inherent difficulty in discriminating orientation, such as the neurophysiological limitations on orientation discrimination proposed by Fellows (1968). From an early stage in development, the human organism is capable of detecting orientation differences. Whether or not orientation will be discriminated in a given situation will depend upon the extent to which conditions elicit attention to similarities or to differences between stimuli and the extent to which the organism is motivated to seek information about identity or orientation.

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FOOTNOTES

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[2]Preliminary analysis revealed no effects for episodes.

Table 1

Analysis of Variance of Familiarisation Data

Source	df	MS	F
Between subjects			
Age (A)	3	830.27	39.97**
Familiarisation Condition (F)	2	305.52	14.71**
A x F	6	54.64	2.63*
$Error_b$	132	20.77	
Within subjects			
Trials (T)	3	56.88	21.75**
A x T	9	9.30	3.55**
F x T	6	19.43	7.43**
A x F x T	18	4.62	1.76*
$Error_w$	396	2.62	

*$p < 0.05$; **$p < 0.001$

Table 2

Analysis of Variance of Violation Data

Source	df	MS	F
Between subjects			
Age (A)	3	105.74	9.12**
Familiarisation Condition (F)	2	472.82	40.76**
A x F	6	29.65	2.56*
$Error_b$	132	11.60	
Within subjects			
Violation Conditions (V)	1	108.17	12.91**
A x V	3	3.09	<1.00
F x V	2	134.34	16.03**
A x F x V	6	19.11	2.28*
$Error_w$	132	8.38	

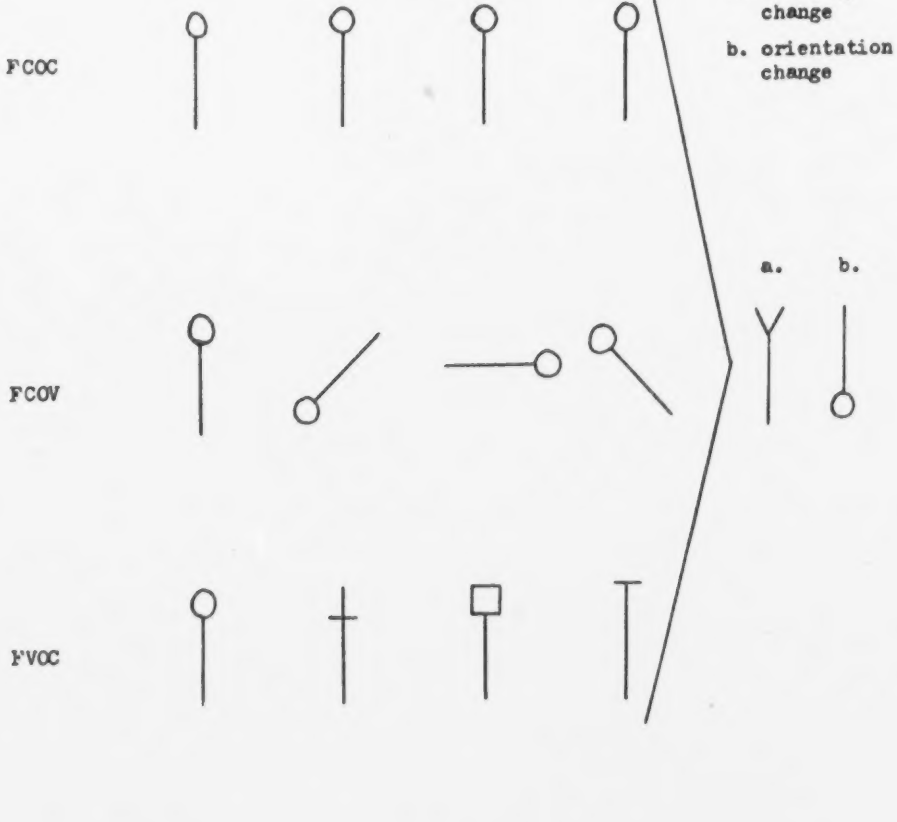
*p<0.05; **p<0.001

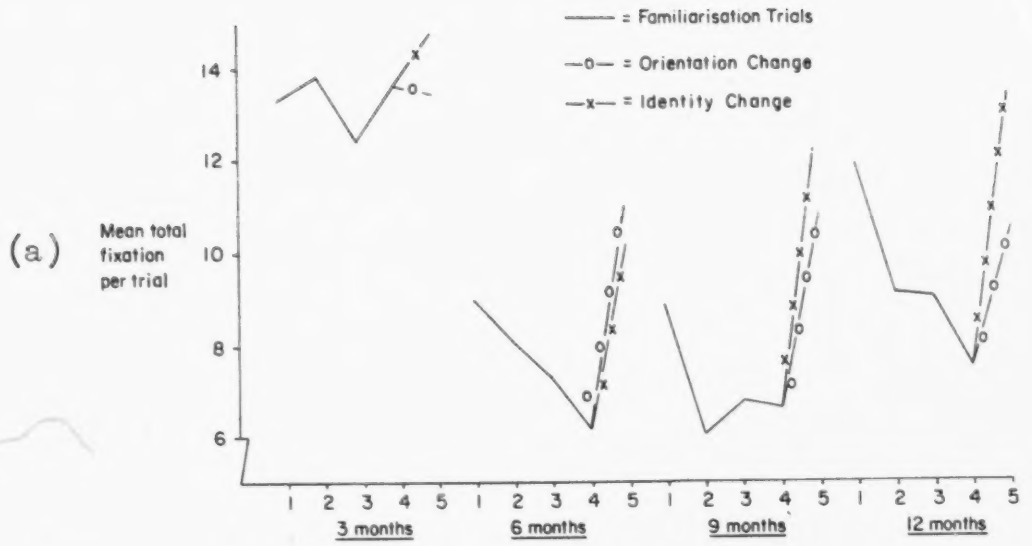
FIGURE CAPTIONS

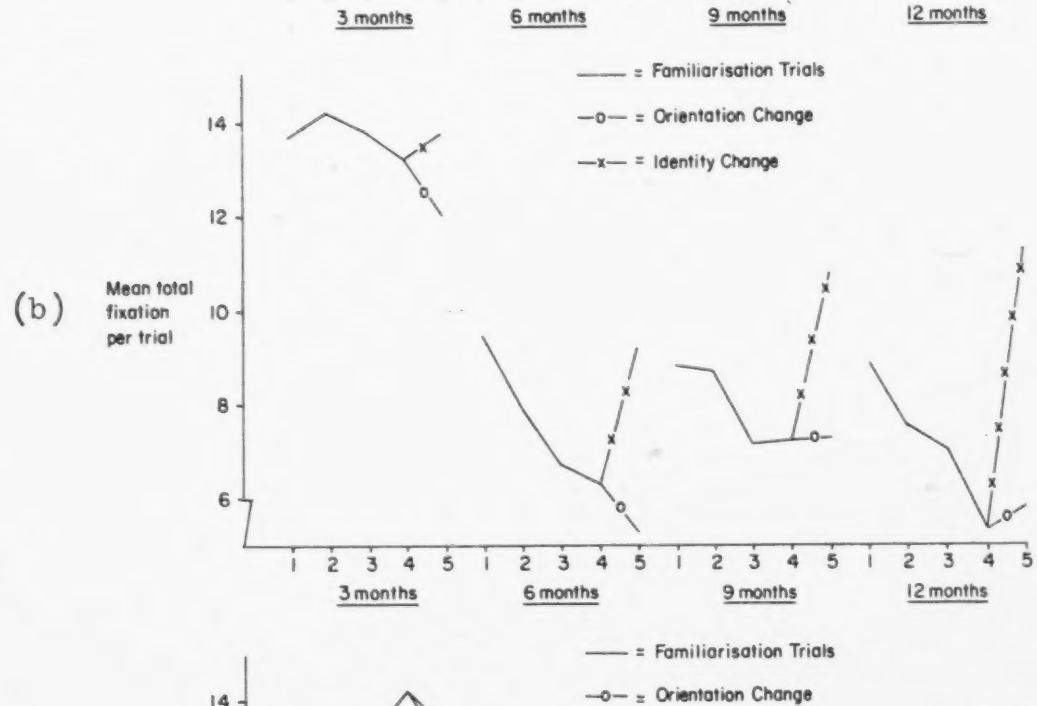
Figure 1. Examples of figures employed as stimuli during familiarisation and violation trials. All subjects experienced the same stimulus at Trial 1, but under FCOV and FVOC conditions the sequence of presentation of stimuli exposed during Trials 2, 3 and 4, was varied randomly. The sequence of presentation of violation stimuli was counter-balanced across subjects.

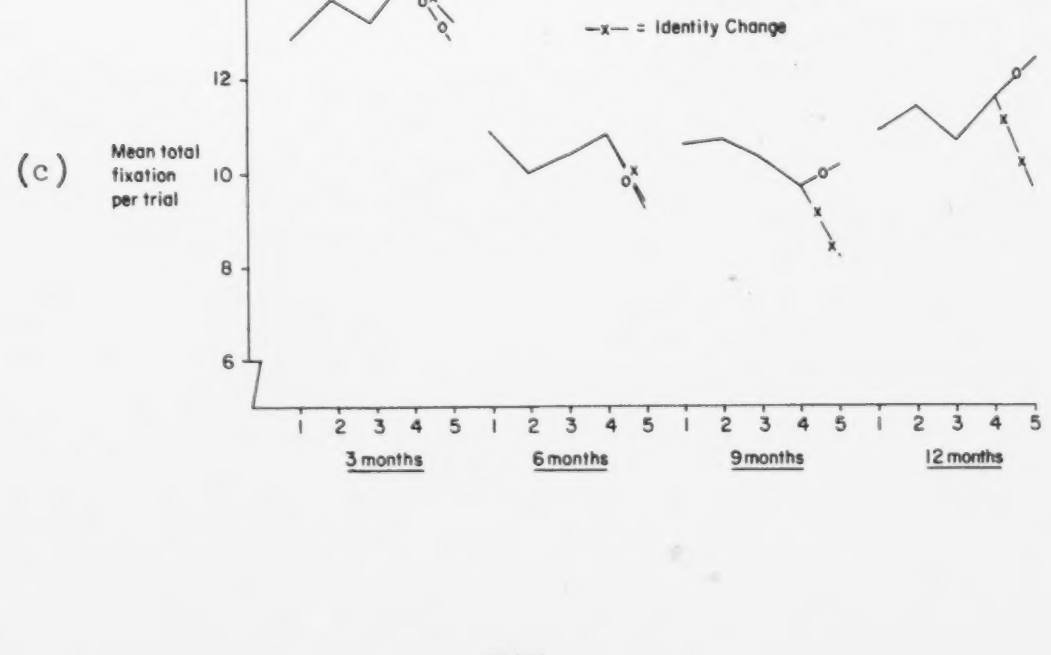
Figure 2. Duration of fixation per trial under (a) FCOC condition, (b) FCOV condition and (c) FVOC condition.

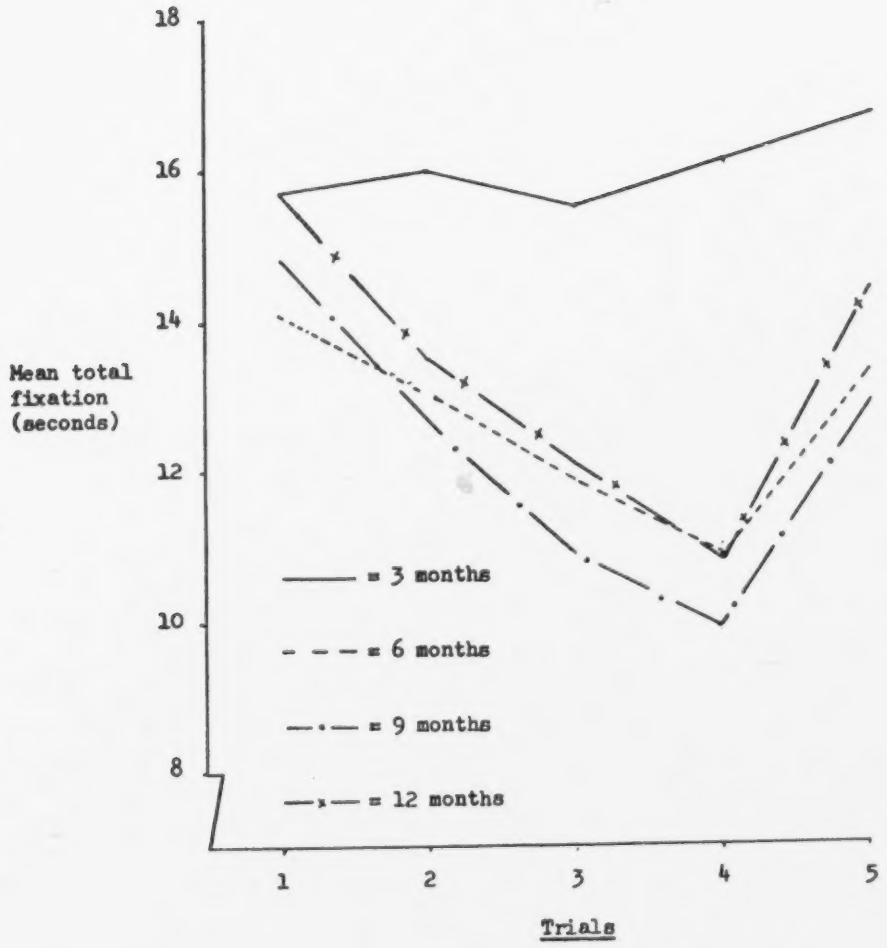
Figure 3. Duration of fixation per trial during filler trials with facial stimulus.


Habituation Condition
Familiarisation Trials
1
2
3
4
Violation Trial
a. identity change
b. orientation change
FCOC
FCOV
FVOC
a.
b.


(a)
Mean total fixation per trial
14
12
10
8
6
—— = Familiarisation Trials
—o— = Orientation Change
—x— = Identity Change
1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
3 months
6 months
9 months
12 months


(b)
Mean total fixation per trial
14
12
10
8
6
—— = Familiarisation Trials
—o— = Orientation Change
—x— = Identity Change
1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
3 months
6 months
9 months
12 months


(c)
Mean total fixation per trial
14
12
10
8
6
—— = Familiarisation Trials
—o— = Orientation Change
—x— = Identity Change
1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
3 months
6 months
9 months
12 months


18
16
14
12
10
8
Mean total fixation (seconds)
= 3 months
= 6 months
= 9 months
= 12 months
1
2
3
4
5
Trials